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(71) Applicant(s)
GEC-Marconi Limited

(Incorporated in the United Kingdom)

The Grove, Warren Lane, STANMORE, Middlesex, HA7 4LY, United Kingdom

(72) Inventor(s)
George Edward Matich
Raymond John Walls
David Henry Ramsey

(74) Agent and/or Address for Service
G Cockayne
GEC Patent Department, Waterhouse Lane, CHELMSFORD, Essex, CM1 2QX, United Kingdom

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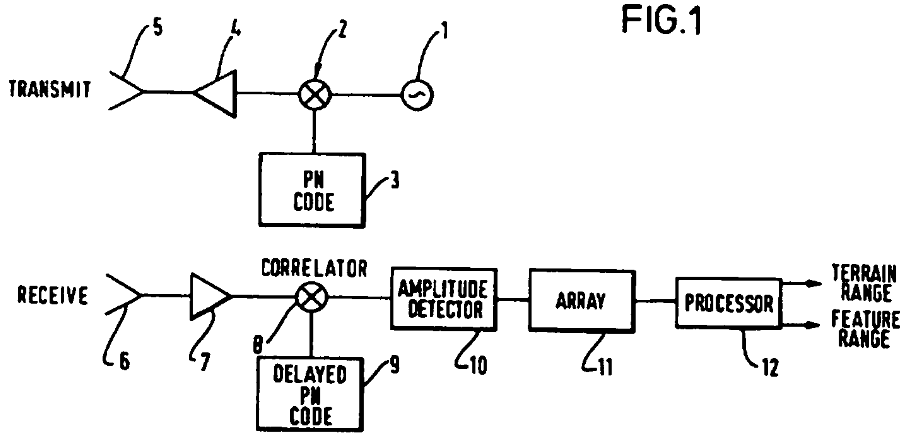
(56) Documents Cited
GB 2122449 A GB 1509464 A US 4758839 A
IEE Proceedings, Vol.133, Part F, No. 2, April 1986, pages 176-186; B. Barboy "Cell-averaging...."

(58) Field of Search
UK CL (Edition K) H4D DRPB DRPE DRPR DSPB DSPE DSPS DSPU
INT CL^5 G01S
Online : WPI, CLAIMS, INSPEC

(54) **Multiple target ranging system**

(57) A continuous wave ranging system comprises a modulator 2 for modulating an r.f. carrier wave in accordance with a pseudo-random code 3, a transmitting antenna 5 for radiating the modulated signal towards a target, a receiving antenna 6 and receiver 7 for detecting the signal reflected back from the target. A correlator 8 correlates the reflected signal with a transmitted code with a selected phase shift 9 corresponding to the current range gate to be tested. In the altimeter described means 10, 11, 12 process the range/amplitude data (Fig 4) from the correlator 8 to discriminate between reflections due to the ground and those due to other features above the ground. Range (R2 Fig 4) to the ground is determined using an area algorithm (Fig 3) based on returns about the greatest amplitude, while range (R1 Fig 4) to the features is based on interpolation at the shortest range producing returns above a threshold.

FIG.1



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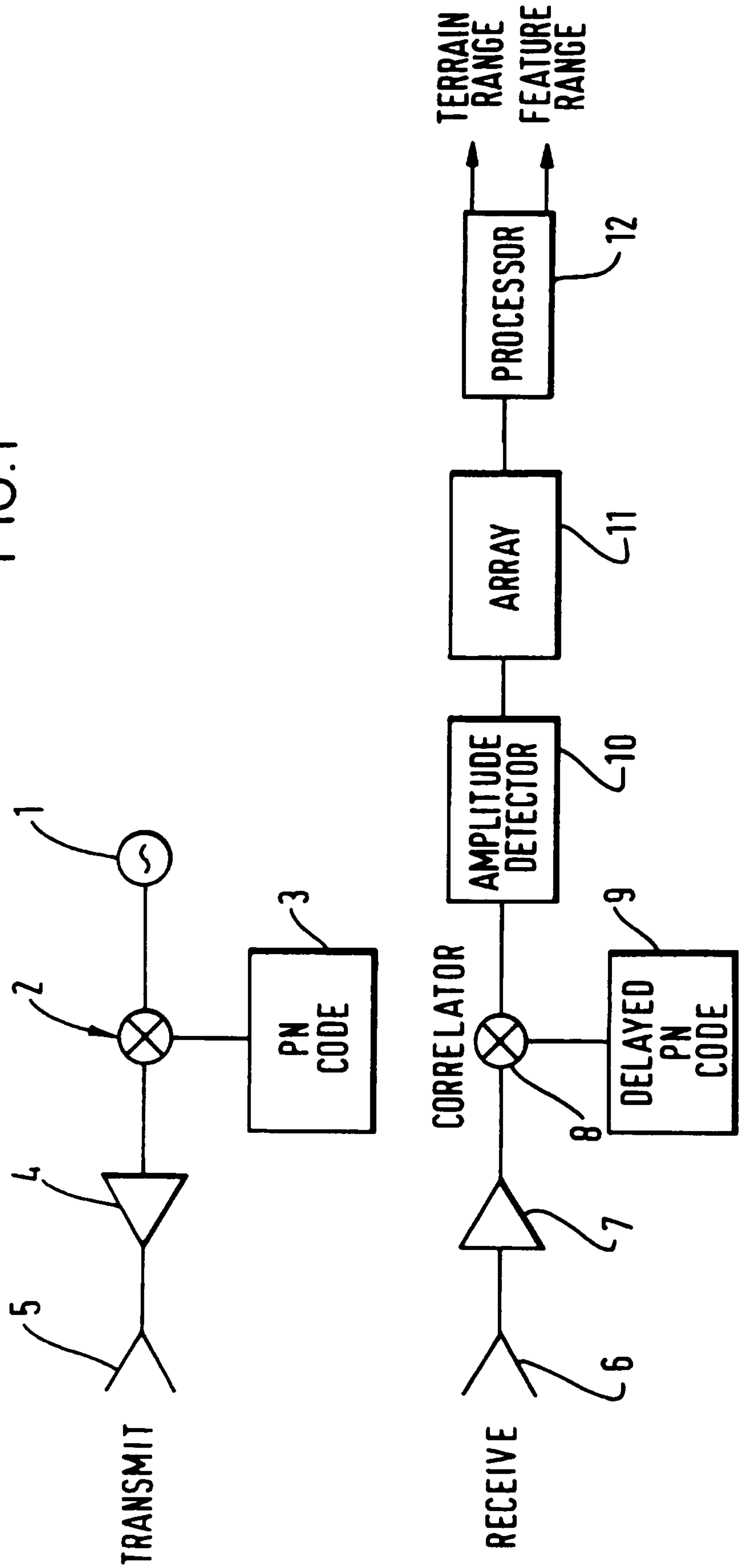
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG.1


TRANSMIT
5
4
2
1
PN CODE
3
RECEIVE
6
7
CORRELATOR
8
DELAYED PN CODE
9
AMPLITUDE DETECTOR
10
ARRAY
11
PROCESSOR
12
TERRAIN RANGE
FEATURE RANGE

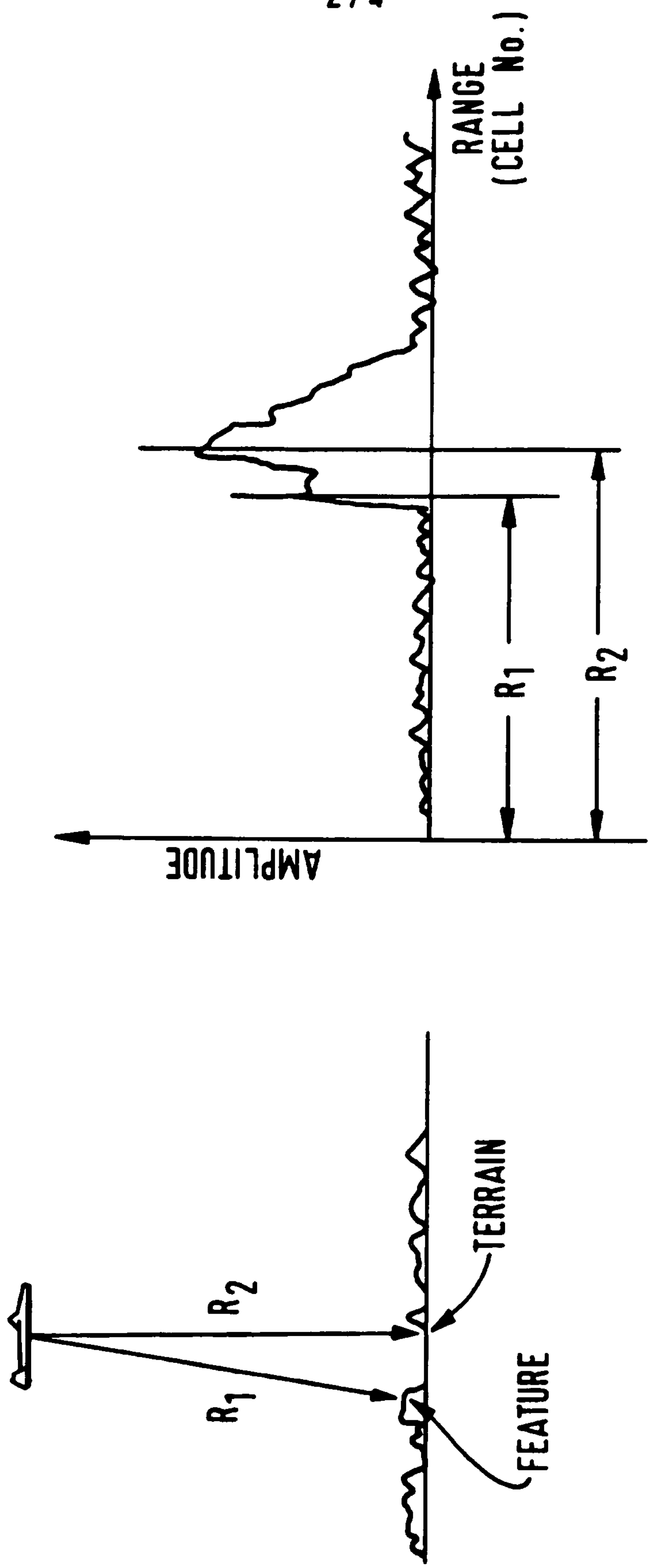


FIG.2

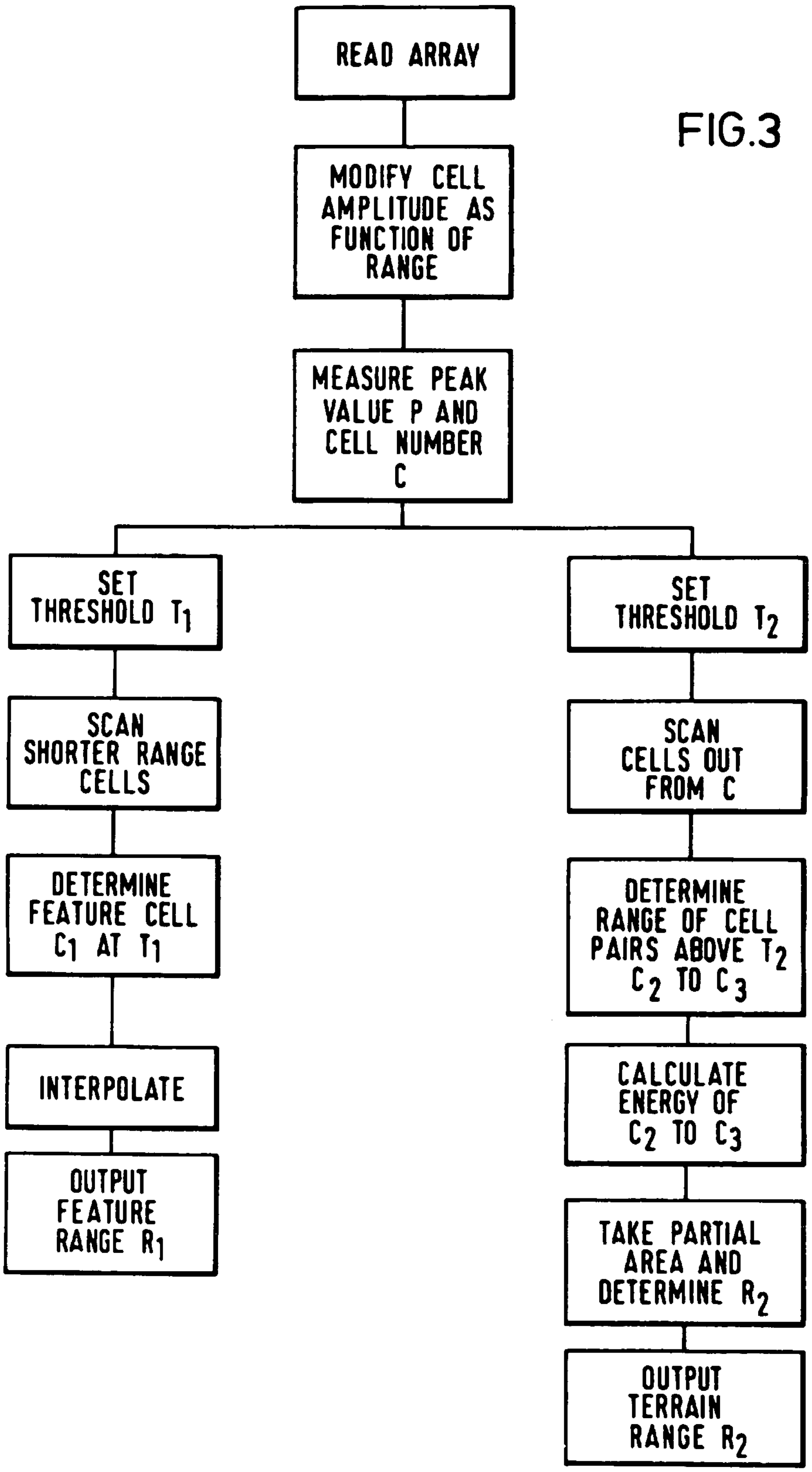


FIG.3

ALGORITHM FOR EXTRACTION OF FEATURE AND TERRAIN RANGES

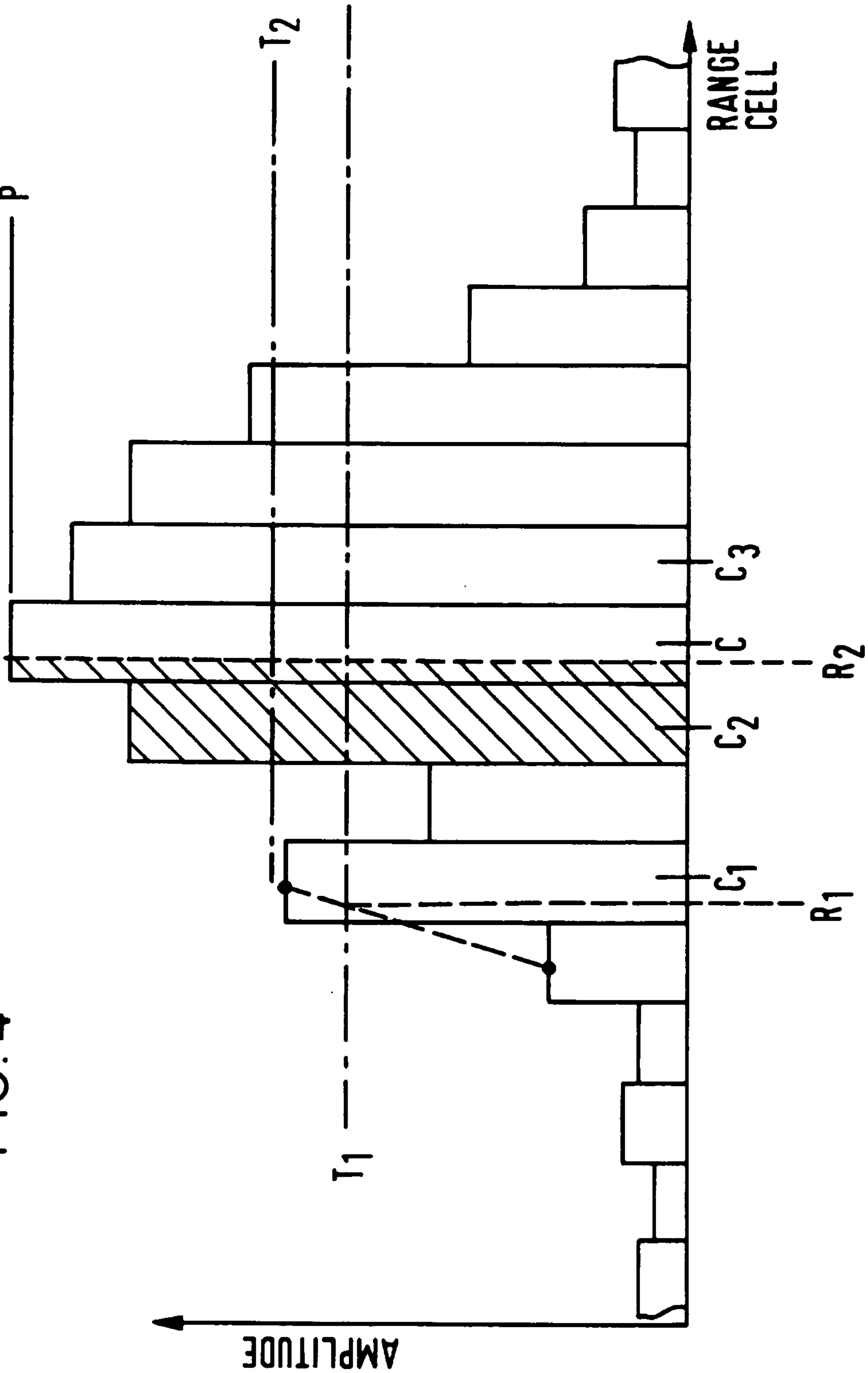


FIG. 4

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MULTIPLE TARGET RANGING SYSTEM

This invention relates to a continuous wave ranging system and, in one aspect, to an aircraft radar altimeter system.

Such systems usually comprise a means of microwave transmission upon which some form of coding has been added, and antenna for directing the energy to the target, an antenna for receiving the returned energy and, after amplification, a means of determining the amount of delay that has occurred on the signal, and hence the range of the target. The coding on the transmission had in the past been pulse or frequency modulation, but more recently phase modulation from a pseudo-random code has been used. This form of modulation has the property of producing a noise-like transmitted spectrum which is difficult to detect and hence finds applications where covertness is of importance. Covertness can be enhanced by reducing the transmitted power such that the returned signal is just sufficient for ranging measurement.

In such phase-modulated systems, the received

signal is correlated with a delayed version of the transmitted code, the delay being gradually increased in steps, and samples of the output of the correlator are detected and stored in an array. From this stored data, the delay, and hence the range, where the received signal return occurs can be found.

Existing direct sequence spread spectrum ranging systems use techniques such as delay locked or Tau dither loops to track target ranges. These techniques result in a narrow tracking window and tracking loops with excellent dynamic performance. However, the narrowness of the tracking window restricts the ability of such systems to see any targets at ranges other than that being tracked.

According to the invention, a continuous wave ranging system comprises a modulator for modulating an r.f. carrier wave in accordance with a pseudo-random code, a transmitting antenna for radiating the modulated signal towards a target, a receiving antenna and receiver for detecting the signal reflected back from the target, a correlator for correlating the reflected signal with the transmitted code with a selected phase shift corresponding to the current range gate to be

tested, and means for processing the range/amplitude data from the correlator to discriminate between reflections due to the target and those due to other objects adjacent to the target.

The pseudo-random code used in the invention is preferably a maximal length code, a sequence of numbers generated by a shift register with certain feedbacks on it. For the system of the present invention, a code length of 2047 digits is preferred.

The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 shows a schematic view of a system according to one embodiment of the inventor,

Figure 2 shows a diagrammatic view of the application of the system and a typical signal received from such a system,

Figure 3 shows one algorithm from the extraction of feature and terrain ranges from the system, and

Figure 4 shows a typical signal reading divided into range cells.

Referring now to Figure 1, the system shown therein comprises a transmitter having a signal generator 1; a modulator 2 for modulating the signal in accordance with a pseudo-random code; a transmitter amplifier 4 and a transmitter antenna 5. A receiver includes a receiver antenna 6; a receiver amplifier 7, a correlator 8 for correlating the received signal with a delayed version of the pseudo-random code 9 according to the range being determined; an amplitude detector 10; a memory array 11 and a processor 12 for analysing the signal stored in the array 11 to determine terrain and feature ranges.

A range scanning technique be used in the above system, where the receiver code is preferably dwelled at a given delay (range) for a fixed integration period enabling signal strength to be measured for each delay period. In turn a picture of signal strength versus range is constructed for the entire measurement range of the system in the array 11. This picture will thus contain signal/range data for all targets as well as environment noise information, a typical result being shown in Figure 2. From this picture, the predominant

target range (terrain) R2 and less dominant shorter ranged targets (feature) R1 may be extracted by use of the processor 12. In order to formulate a robust predominant target extraction technique, regard must be given to target dynamics. It can be shown that a partial area algorithm applied about the predominant target range can significantly discriminate this target from shorter range returns which occur close to it.

One particular method of extracting feature and terrain ranges will now be described with reference to Figures 3 and 4.

Referring now to Figures 3 and 4, the array of amplitudes or signal strengths in the various range bands or range cells is read and the amplitudes are modified to compensate for the law of signal strength versus range, signals reducing at 9 dB/octave due to propagation factors. The cell with the largest amplitude (after compensation) is noted (C) and the amplitude value measured (P).

The method of determining the range of a feature is as follows (left hand side of Figure 3):-

A threshold (T1) is set at a fixed value below P. This is typically 12 dB and a check is made that T1 is above the general noise level. A scan is made of the cells below C starting at a fixed number of cells below C. Typically the scan would start at the equivalent of 300 feet below C although a scan would not normally cover the first few cells, corresponding to ranges below say 15 feet. The cell having the shortest range which has energy above T1 is determined (C1). Interpolation is then made based on the energy in C1 and the energy in the next cell below and from this interpolation R1 is calculated as the range where the T1 threshold is crossed and after filtering is output.

The method of determining the range of the terrain is as follows (right hand side of Figure 3):-

A threshold (T2) is set at a fixed value below P. This need not be the same as T1 but is typically 12 dB when a good signal to noise ratio is obtained. Under poorer signal to noise conditions the threshold will be closer to P. A scan is then made of pairs of cells, comprising one cell in above C and the other below, both by the same amount. When energy in either cell of the scanned pair falls below T2 the scanning is halted. The

range of pairs of cells (C2 - C3) that have energy above T2 is determined. (In the example of Figure 4 only the adjacent pair of cells meets this criterion). The energy in the range of cells C2 - C3 is calculated and the area that contains a fixed fraction K of the total energy in C2 - C3 is calculated, its upper boundary giving the value of R2 (see Figure 4). Typically a value of K is 0.375. After filtering R2 is output as the range to the terrain. The amount of filtering applied to the terrain output can be greater than that of the feature if required.

Thresholds T1 and T2 are chosen so that features such as trees and buildings are accepted and measured whilst returns from clouds and chaff are ignored.

CLAIMS

1. A continuous wave ranging system, comprising a modulator for modulating an r.f. carrier wave in accordance with a pseudo-random code, a transmitting antenna for radiating the modulated signal towards a target, a receiving antenna and receiver for detecting the signal reflected back from the target, a correlator for correlating the reflected signal with a transmitted code with a selected phase shift corresponding to the current range gate to be tested, and means for processing the range/amplitude data from the correlator to discriminate between reflections due to the target and those due to other objects adjacent to the target.

2. A system as claimed in claim 1, wherein a first threshold is determined with regard to the amplitude of the received signals such that the signals immediately above this threshold are signals returned from one or more of said other objects.

3. A system as claimed in claim 1 or 2, wherein a second threshold is set such that an analysis of the energy distribution of so returned signals above said second threshold allows determination of said target range.

4. A system as claimed in any preceding claim, wherein the target is the ground and the other objects are features on the ground.

5. A system as claimed in claim 2, wherein an increasing range scan is made of returned signals from below the range of maximum returned signal strength until the returned signal strength is above the first threshold.

6. A system as claimed in claim 3, wherein a scan is made of pairs of signals above and below the range of maximum returned signal strength until one of said pairs includes a signal below the second threshold, the total energy of the pairs above said threshold is calculated, and the range of a fixed fraction of said total energy determined.

Amendments to the claims have been filed as follows

1. A continuous wave ranging system, comprising a modulator for modulating an r.f. carrier wave in accordance with a pseudo-random code, a transmitting antenna for radiating the modulated signal towards a target, a receiving antenna and receiver for detecting the signal reflected back from the target, a correlator for correlating the reflected signal with a transmitted code with a selected phase shift corresponding to the current range gate to be tested, and means for processing the range/amplitude data from the correlator to discriminate between reflections due to the target and those due to other objects adjacent to the target so as to produce respective range output signals corresponding to the target and to other objects.

2. A system as claimed in claim 1, wherein a first threshold is determined with regard to an amplitude of the received signals such that signals immediately above this threshold are signals returned from one or more of said other objects.

3. A system as claimed in claim 1 or 2, wherein the target range is determined by setting a second

threshold and analysing the energy distribution of returned signals above said second threshold.

4. A system as claimed in any preceding claim, wherein the target is the ground and the other objects are features on the ground.

5. A system as claimed in claim 2, wherein an increasing range scan is made of returned signals from below the range of maximum returned signal strength until the returned signal strength is above the first threshold.

6. A system as claimed in claim 3, wherein a scan is made of pairs of signals above and below a range of maximum returned signal strength until one of said pairs includes a signal below said second threshold, the total energy of the pairs above said threshold is calculated, and the target range determined as the upper boundary of the area that contains a fixed fraction of said total energy.

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Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number

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Relevant Technical fields

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(ii) Int Cl (Edition 5) G01S

Search Examiner

G A McLEAN

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASES WPI, CLAIMS, INSPEC

Date of Search

23 AUGUST 1990

Documents considered relevant following a search in respect of claims 1 - 6

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
Y	GB 2,122,449 A (LICENTIA) - especially pages 3 - 6	1, 3, 4
Y	GB 1,509,464 A (SPERRY) - especially lines 6 - 39, page 2; claim 1	1, 4
X, Y	US 4,758,839 (McDONNEL) - especially column 4	1 - 4
Y	IEE Proceedings, Vol. 133, Part F, No. 2, April 1986, pages 176 - 186 B. Barboy et al "Cell-averaging ..." - especially Sections 1. - 5.	"

SF2(p)